TEKER TORRES & TEKER, P.C.
Suite 2-A, 130 Aspinall Avenue
Hagåtña, Guam 96910-5018
Telephone: (671) 477-9891
Facsimile: (671) 472-2601

STEWART SOKOL & GRAY LLC
2300 SW First Avenue, Suite 200
Portland, Oregon 97201-5047
Telephone: (503) 221-0699
Facsimile: (503) 419-0281

Attorneys for Plaintiff
Maeda Pacific Corporation

IN THE DISTRICT COURT OF GUAM

TERRITORY OF GUAM

MAEDA PACIFIC CORPORATION, a Guam corporation,

Plaintiff,

v.

GMP HAWAII, INC., a Hawaii corporation doing business as GMP ASSOCIATES, OHIO PACIFIC TECH, INC., a Ohio corporation doing business as GMP ASSOCIATES, INC., and GMP ASSOCIATES, INC. (collectively, "GMP"); and JORGENSEN & CLOSE ASSOCIATES, INC., a Colorado corporation,

Defendant.

CIVIL ACTION NO. 08-00012

COMPLAINT

I. JURISDICTION

1.1 Jurisdiction is founded on diversity of citizenship pursuant to 28.U.S.C. § 1332.

/ / /

STEWART SOKOL & GRAY LLC
ATTORNEYS AT LAW
2300 SW FIRST AVENUE, SUITE 200
PORTLAND, OREGON 97201-5047
(503) 221-0699
FAX (503) 223-5706

1.2 Plaintiff Maeda Pacific Corporation ("Maeda Pacific") is a Guam corporation having its principal place of business in the Territory of Guam.

1.3 Defendants GMP Hawaii, Inc. is a Hawaii corporation doing business as GMP Associates. Ohio Pacific Tech, Inc. is an Ohio corporation also affiliated and doing business as GMP Associates, Inc.. These Defendants and their assumed business names and affiliates will be for purposes of this Complaint collectively referred to as "GMP".

1.4 Defendant Jorgensen & Close Associates, Inc. ("J&C") is a Colorado corporation.

1.5 The matter in controversy exceeds, exclusive of interest and costs, the sum of $75,000.

II. GENERAL ALLEGATIONS

2.1 Prior to December 1, 2004, Maeda Pacific commenced the process of preparing a Proposal for the design and construction of an off-base water supply system for Andersen Air Force Base on the Island of Guam. In connection therewith, Maeda Pacific engaged GMP to act as its designer for the design/build project, and to conduct both value engineering in connection with the procurement process and to provide quality control in the event Maeda Pacific was awarded the contract.

2.2 Following the Governments' acceptance of Maeda Pacific's Proposal and in connection therewith, Maeda Pacific and GMP formally entered into an agreement for the design, value engineering and quality control processes of the procurement whereby GMP agreed to perform those tasks for a total fee of Nine Hundred Eighty-one Thousand Two Hundred Forty Dollars ($981,240). During the course of performance of its design work, Change Orders #1, #2 and #3 were executed by Maeda Pacific and GMP, bringing the total fee of GMP to One Million Five Hundred Fifty-five Thousand Nine Hundred Sixty-six and 70/100 Dollars ($1,555,966.70).

STEWART SOKOL & GRAY LLC
ATTORNEYS AT LAW
2300 SW FIRST AVENUE, SUITE 200
PORTLAND, OREGON 97201-5047
(503) 221-0699
FAX (503) 223-5706

2.3 In addition to utilizing and relying upon the accuracy and completeness of GMP's design, Maeda Pacific entered into a subcontract agreement with Smithbridge Guam, Inc. ("Smithbridge") for construction of the reservoir tank and appurtenant sections. In connection therewith and in concert with Smithbridge, Maeda Pacific approved and paid for structural engineering design to be performed by J&C, which included evaluation and design of all aspects of the reservoir tank, including precast and prestress members as well as the reservoir roofing plan, which was to be implemented in connection with the procurement.

2.4 Maeda Pacific was a third party beneficiary of the design contract between Smithbridge and J&C, paid for J&C fees, and specifically relied upon J&C's expertise to properly design the reservoir, including all appurtenant portions, including the roof thereof.

2.5 Upon award of the contract which was officially known as Contract No. N62742-01-C-1355-Replace Off-Base Water Supply System-Andersen Air Force Base, Guam, design work by GMP and J&C commenced.

2.6 Previously the Government had prepared a set of General Specifications which were understood to be utilized by GMP and J&C in connection with their preparation of the final design specifications and design drawings for construction purposes.

2.7 In connection with the commencement of design activities, Maeda Pacific and GMP entered into an agreement, a copy of which is attached hereto as Exhibit "A" and incorporated herein. Change Orders were executed during the course of the work, as alleged above, copies of which are collectively attached as Exhibit "A". In connection with said agreement, GMP agreed to design the large water reservoir tank to be built pursuant to the prime contract and agreed to utilize its best professional skill and

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STEWART SOKOL & GRAY LLC
ATTORNEYS AT LAW
2300 SW FIRST AVENUE, SUITE 200
PORTLAND, OREGON 97201-5047
(503) 221-0699
FAX (503) 223-5706

knowledge to prepare the Plans and Specifications and other information, and the ultimate design for said tank.

2.8 J&C similarly agreed to utilize their best professional skill and knowledge to assist in connection with the preparation of all structural and related design work in connection with the procurement.

2.9 During the course of the design work, both Defendants GMP and J&C were specifically aware of the venting requirements which were set forth in the General Design Specifications furnished by the Department of the Navy.

2.10 Maeda Pacific has performed all conditions precedent, conditions and obligations on its part to be performed.

III. COUNT ONE - NEGLIGENCE

3.1 Defendants GMP and J&C were negligent in the design of the water tank by virtue of their failure to provide any vents or ventilating system for the tank, as specifically required by the Department of the Navy General Specifications and as would normally have been required to be included in the design in the exercise of good engineering practice.

3.2 As a result of the negligence of Defendants, the reservoir roof collapsed as the proximate result of the absence of vents, ventilating systems or ventilators. The proximate cause of the collapse was determined by an independent engineering firm, Wiss, Janney, Elstner Associates, Inc. to be caused by the absence of air vents within the tank. A complete copy of the independent report dated September 5, 2007 is attached hereto an incorporated herein as Exhibit "B".

3.3 By virtue of the professional negligence of Defendants, Maeda Pacific was required to redesign the tank and reconstruct the roof and appurtenant parts of the tank, all to Maeda Pacific's damage in an amount not less than Five Million Dollars ($5,000,000). In addition, Maeda Pacific has been damaged by virtue of the delays

STEWART SOKOL & GRAY LLC
ATTORNEYS AT LAW
2300 SW FIRST AVENUE, SUITE 200
PORTLAND, OREGON 97201-5047
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FAX (503) 223-5706

occasioned by the collapse, redesign and reconstruction, and is exposed to the imposition of liquidated damages by the owner in an amount in excess of One Million Dollars ($1,000,000).

IV. COUNT TWO - BREACH OF CONTRACT

4.1 Maeda Pacific realleges and incorporates herein the allegations contained in paragraphs 1.1 through 3.3.

4.2 Defendants contractually agreed to provide a design which was consistent with the requirements of the general Department of the Navy Design Manual and to utilize their best engineering and design expertise in the performance of their duties.

4.3 Defendants materially breached their contract by failing to exercise proper engineering judgment in the design of the reservoir, appurtenant parts and roof thereof, and as a direct and proximate cause of their breaches of contract, Maeda Pacific has been damaged in an amount not less than Five Million Dollars ($5,000.000) for redesign, reconstruction costs and related damages and at least One Million Dollars ($1,000,000) liquidated damages, all proximately caused by the contract breaches of Defendants.

V. COUNT THREE - BREACH OF CONTRACT

5.1 Maeda Pacific realleges and incorporates herein the allegations contained in paragraphs 1.1 through 4.3.

5.2 With respect to Defendant GMP, GMP agreed to conduct value engineering services during the course of design, prepare the Operation and Maintenance Support Information or Manual ("OMSI"), prepare as-built drawings, shop drawings and cost overruns, and to provide quality control during the course of performance of the design and construction of the water reservoir, appurtenant portions and roof thereof.

5.3 In breach thereof, Defendant GMP provided no value engineering for the project, failed to prepare the OMSI Manual; and failed to complete the quality control

/ / /

STEWART SOKOL & GRAY LLC
ATTORNEYS AT LAW
2300 SW FIRST AVENUE, SUITE 200
PORTLAND, OREGON 97201-5047
(503) 221-0699
FAX (503) 223-5706

work, to Maeda Pacific's damage in an amount not less than One Million Eight Hundred Thousand Dollars ($1,800,000).

WHEREFORE, Maeda Pacific Corporation prays that it be awarded judgment against Defendants with respect to Counts One and Two of the Complaint in an amount not less than Six Million Dollars ($6,000,000), and on Count Three against Defendant GMP in a further amount of not less than One Million Eight Hundred Thousand Dollars ($1,800,000), together with interest, attorneys fees and costs, and all other and further relief that Maeda Pacific is entitled to.

DATED at Hagåtña, Guam this 13th day of August, 2008.

TEKER TORRES & TEKER, P.C.

By: _____
SAMUEL S. TEKER, ESQ., Attorneys for Plaintiff, ***Maeda Pacific Corporation***

STEWART SOKOL & GRAY LLC

By: _____
JOHN SPENCER STEWART, ESQ., Attorneys for Plaintiff, ***Maeda Pacific Corporation***

STEWART SOKOL & GRAY LLC
ATTORNEYS AT LAW
2300 SW FIRST AVENUE, SUITE 200
PORTLAND, OREGON 97201-5047
(503) 221-0699
FAX (503) 223 5706

TERMS OF AGREEMENT
ANDERSEN AIR FORCE BASE OFF-SITE WATER SYSTEM DESIGN-BUILD
BETWEEN
MAEDA PACIFIC CORPORATION AND GMP ASSOCIATES

CONTRACT A - DESIGN:	$	645,000.00
CONTRACT B - QUALITY CONTROL:	$	336,240.00
TOTAL:	$	981,240.00

TERMS AND CONDITIONS AND SCOPE OF WORK:

As outlined and detailed in the project contract between Maeda Pacific Corporation and Pacific Division Engineering, Naval Facilities Command for the design-build of the Andersen Air Force Base Off-Site Water System.

All legal terms and conditions shall be as outlined in the bid documents.

VALUE ENGINEERING:

At the halfway point of construction, MPC and GMP shall evaluate the budgetary status of the project to allot for the $100,000 construction quality control budget shortfall. MPC and GMP shall work diligently to identify the source of savings to fund this shortfall.

Additionally, GMP Associates shall conduct Value Engineering on the bid and 30% design documents provided by the U.S. Navy. Any Value Engineering Savings beyond the $100,000 for construction quality control shall be equally divided between Maeda Pacific and GMP.

PAYMENT SCHEDULE:

DESIGN (A):

GMP will bill Maeda Pacific for the design on the basis of monthly progress. Total design fee shall be $645,000.00

CONSTRUCTION QUALITY CONTROL (B):

$43,600/Month (Total: $436,000)

The above terms and conditions represent the parameterss which Maeda Pacific and GMP Associates are operating within in the design-build Andersen Air Force Base Off-Site Water Supply Project. These terms are not intended to be restrictive, rather to facilitate the execution of the project.

Takeo Ando, Maeda Pacific Corporation

Peter B. Melnyk, GMP Associates, Inc.

EXHIBIT A, PAGE 1 OF 8

MAEDA PACIFIC CORPORATION
GENERAL CONTRACTOR

June 12, 2006

Peter B. Melnyk, P.E., Ph.D
Executive Vice President
GMP & Associates, Inc.
125 Tun Jesus Crisostomo St.
Sunny Plaza, Suite 306
Tamuning, Guam 96913

Project: Replace Off-Base Water Supply System Design-Build, AAFB
Contract No. N62742-01-C-1355

Subject: **Change Order #1, #2 & #3**

Herewith are the Subcontract Agreements for Change Order #1, #2 & #3.

Change Order #1	$ 249,115.84
Change Order #2	$ 204,050.86
Change Order #3	$ 121,560.00

The above subject has been fully paid and that the acknowledgement of this agreement is just for accounting purposes. Please sign and return to our office.

Should you have any questions regarding this matter, please do not hesitate to call.

Sincerely,

Tsutomu Yamakawa
Vice-President

RCD BY:
CONNIE DIAZ
06-12-06 2:22 PM

SUBCONTRACT AGREEMENT

Made as of this *1st* day of *September* year *2004*, between *MAEDA PACIFIC CORPORATION* (hereinafter called the *Contractor*) and *GMP & Associates* (Known to be the *Subcontractor*).

The Name of the project is: ***Replace Off-Base Water Supply System at Andersen Air Force Base. Change Order # 1 for Design Cost and Q.C. Specialist.***

The subcontract amount is: ***Two Hundred Forty Nine Thousand One Hundred Fifteen and 84/100 only. ($ 249,115.84).***

Completion Date: ***December 31, 2004***

A. The ***Subcontractor*** shall pay for all materials, equipment and labor used in the connection with the performance of this Subcontract, except as noted.

The ***Subcontractor*** shall comply with federal, state and local tax laws, social security acts, workmen's compensation acts insofar as applicable to the performance of this Subcontract.

C. The ***Subcontractor*** shall take reasonable safety precautions with respect to the performance of this Subcontract, shall comply with safety measures, and applicable laws, ordinances, rules, regulations and orders of public authorities for the safety of persons or property.

D. The ***Subcontractor*** warrants to the Contractor that materials and equipment furnished under this Subcontract will be of good quality. Work not conforming to these requirements, including substitution not properly approved and authorized by the Contractor may be considered defective and ordered removed.

Payment will be based only the quantity installed by the Subcontractor with the corresponding unit price per Pay Item, Application for payment will be submitted each month together with Payroll Certification. The Contractor shall pay the Subcontractor the full amount less **0 %** retention, determined and agreed by the ***Contractor*** and ***Subcontractor***.

F. Final payment, constituting the entire unpaid balance of the Subcontractor Sum, shall be made by the Contractor to the Subcontractor when the Subcontractor's work is 100% and satisfactory to the Contractor.

Before issuance of the final payment, the ***Subcontractor***, if required shall submit evidence satisfactory to the Contractor that payrolls, bill for materials and equipment, and all known indebtedness connected with the Subcontractor's work have been satisfied.

H. The ***Subcontractor*** shall attend the ***Contractor's Monthly Safety Meeting*** held on the first working day of the month. The subcontractor's failure to attend this meeting will result to a ***$500.00*** fine, which the Contractor shall deduct from the Subcontractor's billing.

I. ***Scope of work:*** See attachment *(Proposal)*.

This agreement entered into as of the day and year first written above.

CONTRACTOR:

Yamakawa

Yutomu Yamakawa
Vice-President
Maeda Pacific Corporation.

SUBCONTRACTOR:

Peter B. Melnyk, P.E., Ph.D.
Executive Vice President
GMP & Associates, Inc.

EXHIBIT A, PAGE 3 OF 8

Sub – Contractor : GMP & Associates,Inc

Item	Original Contruct				CO#1				Up to CO#1		
Design	1	LS	$645,000.00	$645,000.00					1	LS	$645,000.00
QC Specialist & QC	1	LS	$336,240.00	$336,240.00					1	LS	$336,240.00
CO #1Design Cost					1	LS	$249,115.84	$249,115.84	1	LS	$249,115.84
Total Amount				$981,240.00				$249,115.84			$1,230,355.84

Sep. 01. 04

Dec 31. 04

No Retention

EXHIBIT A, PAGE 4 OF 8

SUBCONTRACT AGREEMENT

Made as of this *1st* day of *July* year *2005*, between *MAEDA PACIFIC CORPORATION* (hereinafter called the *Contractor*) and *GMP & Associates* (Known to be the *Subcontractor*).

The Name of the project is: ***Replace Off-Base Water Supply System at Andersen Air Force Base. Change Order # 2 for Design Cost and Q.C. Specialist.***

The subcontract amount is: ***Two Hundred Forty Thousand Fifty and 86/100 only. ($ 204,050.86).***

Completion Date: ***December 31, 2005***

A. The ***Subcontractor*** shall pay for all materials, equipment and labor used in the connection with the performance of this Subcontract, except as noted.

B. The ***Subcontractor*** shall comply with federal, state and local tax laws, social security acts, workmen's compensation acts insofar as applicable to the performance of this Subcontract.

C. The ***Subcontractor*** shall take reasonable safety precautions with respect to the performance of this Subcontract, shall comply with safety measures, and applicable laws, ordinances, rules, regulations and orders of public authorities for the safety of persons or property.

D. The ***Subcontractor*** warrants to the Contractor that materials and equipment furnished under this Subcontract will be of good quality. Work not conforming to these requirements, including substitution not properly approved and authorized by the Contractor may be considered defective and ordered removed.

E. Payment will be based only the quantity installed by the Subcontractor with the corresponding unit price per Pay Item, Application for payment will be submitted each month together with Payroll Certification. The Contractor shall pay the Subcontractor the full amount less **0 %** retention, determined and agreed by the ***Contractor*** and ***Subcontractor***.

F. Final payment, constituting the entire unpaid balance of the Subcontractor Sum, shall be made by the Contractor to the Subcontractor when the Subcontractor's work is 100% and satisfactory to the Contractor.

Before issuance of the final payment, the ***Subcontractor,*** if required shall submit evidence satisfactory to the Contractor that payrolls, bill for materials and equipment, and all known indebtedness connected with the Subcontractor's work have been satisfied.

H. The ***Subcontractor*** shall attend the ***Contractor's Monthly Safety Meeting*** held on the first working day of the month. The subcontractor's failure to attend this meeting will result to a ***$500.00*** fine, which the Contractor shall deduct from the Subcontractor's billing.

I. *Scope of work:* See attachment *(Proposal)*.

This agreement entered into as of the day and year first written above.

CONTRACTOR:

Yamakawa

Yutomu Yamakawa
Vice-President
Maeda Pacific Corporation.

SUBCONTRACTOR:

Peter B. Melnyk, P.E., Ph.D.
Executive Vice President
GMP & Associates, Inc.

EXHIBIT A, PAGE 5 OF 8

Sub – Contractor : GMP & Associates,Inc

Item	Up to CO #1 Contruct Amount				CO#2				Up to CO#2		
Design	1	LS	$645,000.00	$645,000.00					1	LS	$645,000.00
QC Specialist & QC	1	LS	$336,240.00	$336,240.00					1	LS	$336,240.00
CO #1Design Cost	1	LS	$249,115.84	$249,115.84					1	LS	$249,115.84
CO #2Design Cost					1	LS	$204,050.86	$204,050.86	1	LS	$204,050.86
Total Amount				$1,230,355.84				$204,050.86			$1,434,406.70

July. 01. 08

2

Rec. 31. 07

No Retention

SUBCONTRACT AGREEMENT

Made as of this *1st* day of *November* year *2005*, between ***MAEDA PACIFIC CORPORATION*** (hereinafter called the *Contractor*) and *GMP & Associates* (Known to be the *Subcontractor*).

The Name of the project is: ***Replace Off-Base Water Supply System at Andersen Air Force Base.***
Change Order # 3 for Design Cost and Q.C. Specialist.

The subcontract amount is: ***One Hundred Twenty One Thousand Five Hundred Sixty and 00/100 only. ($ 121,560.00).***

Completion Date: ***December 31, 2005***

A. The ***Subcontractor*** shall pay for all materials, equipment and labor used in the connection with the performance of this Subcontract, except as noted.

B. The ***Subcontractor*** shall comply with federal, state and local tax laws, social security acts, workmen's compensation acts insofar as applicable to the performance of this Subcontract.

C. The ***Subcontractor*** shall take reasonable safety precautions with respect to the performance of this Subcontract, shall comply with safety measures, and applicable laws, ordinances, rules, regulations and orders of public authorities for the safety of persons or property.

D. The ***Subcontractor*** warrants to the Contractor that materials and equipment furnished under this Subcontract will be of good quality. Work not conforming to these requirements, including substitution not properly approved and authorized by the Contractor may be considered defective and ordered removed.

E. Payment will be based only the quantity installed by the Subcontractor with the corresponding unit price per Pay Item, Application for payment will be submitted each month together with Payroll Certification. The Contractor shall pay the Subcontractor the full amount less **0 %** retention, determined and agreed by the *Contractor* and *Subcontractor*.

F. Final payment, constituting the entire unpaid balance of the Subcontractor Sum, shall be made by the Contractor to the Subcontractor when the Subcontractor's work is 100% and satisfactory to the Contractor.

Before issuance of the final payment, the ***Subcontractor***, if required shall submit evidence satisfactory to the Contractor that payrolls, bill for materials and equipment, and all known indebtedness connected with the Subcontractor's work have been satisfied.

H. The ***Subcontractor*** shall attend the ***Contractor's Monthly Safety Meeting*** held on the first working day of the month. The subcontractor's failure to attend this meeting will result to a ***$500.00*** fine, which the Contractor shall deduct from the Subcontractor's billing.

1. *Scope of work:* See attachment *(Proposal).*

This agreement entered into as of the day and year first written above.

CONTRACTOR:

Tomu Yamakawa
Vice-President
Maeda Pacific Corporation.

SUBCONTRACTOR:

Peter B. Melnyk, P.E., Ph.D.
Executive Vice President
GMP & Associates, Inc.

EXHIBIT A, PAGE 7 OF 8

Sub – Contractor : GMP & Associates,Inc

Item	Up to CO #2 Contruct Amount				CO#3				Up to CO#3 Total Amount		
Design	1	LS	$645,000.00	$645,000.00					1	LS	$645,000.00
QC Specialist & QC	1	LS	$336,240.00	$336,240.00					1	LS	$336,240.00
CO #1Design Cost	1	LS	$249,115.84	$249,115.84					1	LS	$249,115.84
CO #2Design Cost	1	LS	$204,050.86	$204,050.86					1	LS	$204,050.86
Additional QC					1	LS	$121,560.00	$121,560.00	1	LS	$121,560.00
Total Amount				$1,434,406.70				$121,560.00			$1,555,966.70

N.V. 0/. 0f

2

Rec. 3/. 0f

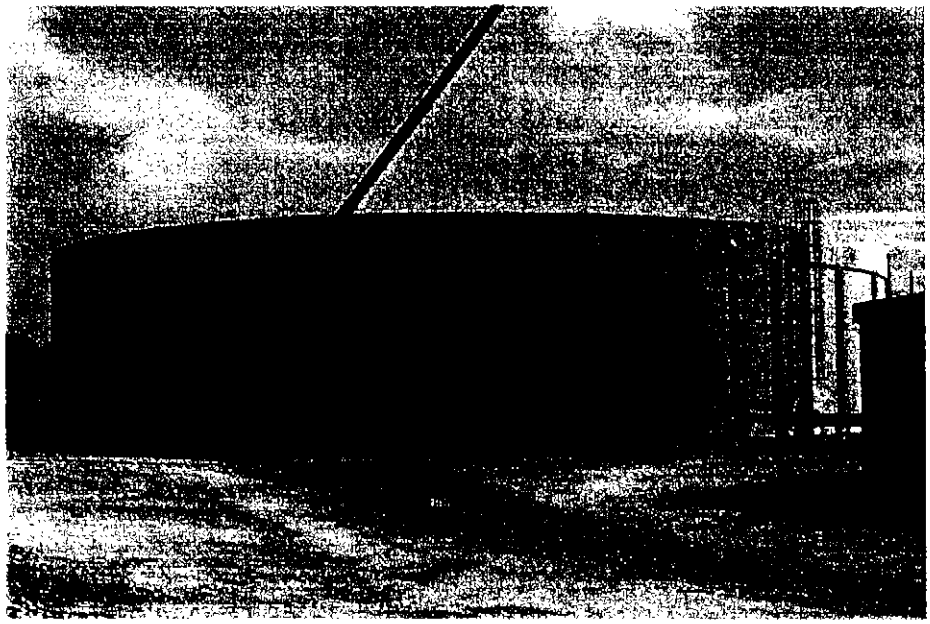
N. Retention

EXHIBIT 4, PAGE 8 OF 8

WJE

ANDERSEN AIR FORCE BASE
Water Tank Roof Collapse

Andersen Air Force Base
Guam



Final Report
5 September 2007
WJE No. 2007.3637

SMITHBRIDGE

Prepared for:
Smithbridge

Prepared by:
Wiss, Janney, Elstner Associates, Inc.

EXHIBIT B, PAGE 1 OF 13

WJE

ANDERSEN AIR FORCE BASE
Water Tank Roof Collapse

Andersen Air Force Base
Guam

Duane L. N. Lee, Project Manager

Final Report
5 September 2007
WJE No. 2007.3637

SMITHBRIDGE

Prepared for:
Smithbridge
Guam Office
P.O. Box 11700
Yigo, Guam 96929

Prepared by:
Wiss, Janney, Elstner Associates, Inc.
1240 Ala Moana Boulevard, Suite 120
Honolulu, Hawaii 96814
808.591.2728 tel | 808.591.2620 fax

EXHIBIT B, PAGE 2 OF 13

WJE | ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

ANDERSEN AIR FORCE BASE

Water Tank Roof Collapse

Andersen Air Force Base
Guam

Introduction

At approximately 9:05 a.m. on 12 July 2007, Guam time, the roof structure over the 12,320 kiloliter concrete water tank collapsed at Andersen Air Force Base, Guam. The tank was recently constructed and filled only for the second time when the collapse occurred. As result of the collapse, Wiss, Janney, Elstner Associates, Inc. (WJE) was engaged by Smithbridge, the sub-contractor responsible for the construction of the tank, to determine its cause. For this engagement, Dr. Duane L.N. Lee of the Hawaii branch of WJE traveled to Guam on 24 July 2007 to investigate the collapse. The details and findings of our investigation are presented in this report.

Our investigation on this project is limited to the design and construction of the water tank. Other conditions associated with this project are beyond our scope of work.

Background

The concrete water tank is part of design-built Contract No. N62742-01-6-1355, FY03 MCAF Replace Off-Base Water Supply System, Andersen Air Force Base, Guam, with the United States Navy. The contract was awarded to Maeda Pacific Corporation, general contractors. Maeda, in-turn, engaged GMP Associates, Inc., Honolulu, Hawaii to undertake the overall design of the project. The structural design of the tank was undertaken by Jorgensen & Close Associates, Inc., Golden, Colorado. Smithbridge, Guam manufactured the precast members and undertook the construction of the tank. The design of the water tank is provided in NAFAC Drawings Nos. 7976362 through 7976594, dated 12 October 2005.

The construction of the water tank commenced approximately on 5 May 2005. The concrete topping for the roof was cast on 25 January 2007. A fluid applied coating reinforced with a fabric had been applied to the roof deck for waterproofing prior to the collapse.

Tank Description

The concrete water tank is a cylindrical structure with an inside diameter of 44.196 meters (m). From the floor level inside the tank, the walls extend 9.238 m vertically. The design of the tank includes a 0.152 m foundation slab reinforced primarily with unbonded post-tensioned tendons. The slab contains an upturn thicken edge of 0.356 m in addition to the slab thickness to support the tank walls at the perimeter of the tank. Five 2.286 m square by 0.406 m thick concrete footings are cast in one line over the foundation slab to support the row of precast concrete columns located below the ridge line of the roof structure.

The concrete walls of the tank consist of 28 precast and vertically prestressed segments. Each segment contains horizontal ducts for the post-tensioning of the tank walls. At the precast wall joints, a 0.381 m separation is provided to couple the post-tensioning ducts and is later filled with cast-in-place concrete. The infilled sections were originally flush with the inside surface of the tank and extended 0.102 m beyond the exterior wall line. During stressing of the tank walls, concrete spalling developed at the joint between the precast wall and the infill section. As a result of issues related to the spalling, a 0.508 m wide by 0.092 m thick vertical concrete section was cast on the inside face of the tank, centered over the infill section.

At four equally spaced locations along the circumference of the tank, the precast wall panels contain exterior faced pilasters for the daylighting and stressing of the tendons. After stressing, the ducts were reported to be grouted.

The tank roof contains a central ridge line, with the roof surface sloped 2 percent to the perimeter tank wall. Scuppers extending through the tank walls remove water from the roof deck. The roof structure is constructed with precast elements beneath a 0.076 m cast-in-place bonded topping. The primary support for the roof structure is provided by a 0.140 m continuous ledger constructed into the precast walls and the five precast columns under the roof ridge. The framing for the roof structure includes the five precast columns with haunches supporting precast, prestressed inverted tee beams. The outside columns have orthogonal haunches supporting precast, prestressed rectangular beams that extend to the wall ledge. The field of the roof structure consists of the following precast, prestressed elements: solid planks spanning between the wall ledges and rectangular beams, and double tees spanning between the wall ledges and the flanges of the inverted tees.

A welded connection between embedded steel elements was specified at the top of the column to inverted tee joint.

The rectangular and inverted tee beams, and double tees are provided with 13 mm and 10 mm diameter U bars at 2.438 m 0.305 m, and 1.219 m intervals, respectively, that extend from the web of the member into the topping for interconnection and composite action. The topping is reinforced with 13 mm bars spaced at 0.305 m on centers, each way.

To lock the topping into the tank walls, the drawings specify a horizontal 76 mm wide by 76 mm high notch within the tank walls to serve as a shear key for approximately 50 percent of the circumference.

The drawings indicate the tank roof is designed to support a live load of 0.96 kiloPascal (kPa) (reducible). The drawings also indicate all precast/prestressed materials and construction shall conform to the *Prestressed Concrete Building Code Requirements* reported by the Precast/Prestressed Concrete Institute, and the *Building Code Requirements for Reinforced Concrete (ACI 318)*.

Water Tank Function

The water tank was designed and constructed as a reservoir for the storage of potable water for general and fire hydrant use. The tank is filled by pumps at several wells located offsite. The water to fill the tank is discharged from a supply line located near the underside of the roof. A 0.50 m diameter overflow drain extends 8 m above the deck of the tank and at a minimum of 46 mm from the underside of the double tees. The supply line is located 0.20 m above the overflow drain.

The water from the tank can be discharged using several options. One is through a 0.40 m diameter floor drain.

Both the overflow drain and the floor drain extend and discharge into a manhole a short distance outside the tank. The end of both drain lines contains a check valve formed of crimped tubing (Fig. 1). (The crimp opens during discharge and remains closed at other times.) The manhole discharges into the base of a ponding basin (Fig. 2) that eventually overflows onto an open plain (Fig. 3). As constructed, the filling of the ponding basin will fill the manhole with water to produce a submerged condition for the drain lines.

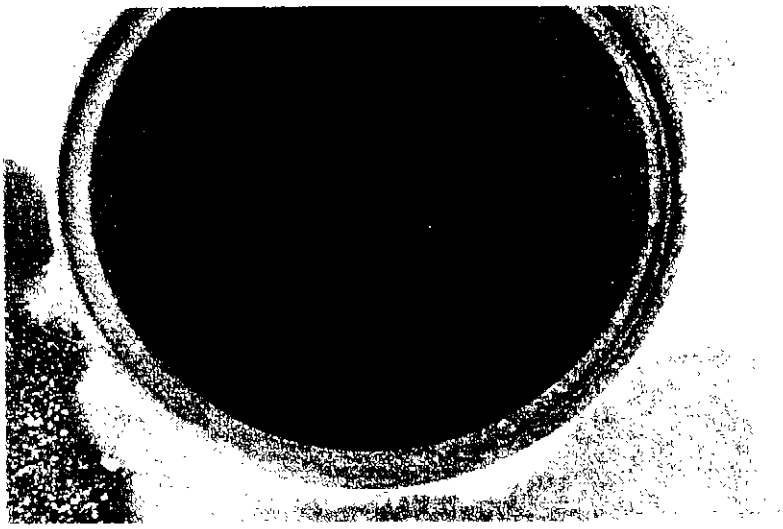


Figure 1. Floor drain and overflow drain lines that discharge into a manhole. The lines terminate with a manufactured crimped end to serve as a check value.

At the roof level, the tank contains a typical roof hatch with ladders mounted on the inside and outside of the tank for access. Notably absent from the tank design are roof or wall top openings intended for venting of the the tank.

Figure 2. Water from the manhole that is discharged near the base of the ponding basin.

Figure 3. Water from the ponding basin that overflows onto the open plain.

Collapse Details

As reported, the water tank roof collapsed on 12 July 2007 after the tank had been filled. This represents only the second time that the tank had been filled after construction. Immediately prior to the collapse, the tank was reported to be full as observed by water overflowing the ponding basin at 8:50 a.m. The overflowing water was assumed to be from the overflow drain within the tank. At 8:55 a.m., directions were given to proceed to the area near Well 3A to open several fire hydrants to circumvent additional water flow to the tank. At approximately 9:00 a.m., several popping sounds were heard outside the tank before collapse of the roof structure at approximately 9:05 a.m. (Fig. 4). After the collapse, the floor drains were opened at approximately 9:15 a.m. At 9:30 a.m., photographs taken from an adjoining higher elevation location indicated the water level to be near the top of the tank (Fig. 5). At the time of the collapse, no significant live loads were on the tank roof. After the collapse, the tank continued to be water tight for all practical purposes. The draining of the tank continued after the roof collapse.

Figure 4. Collapse of the roof structure within the tank.

As noted, the collapse represented only the second time the tank had been filled. On the first occasion, the tank was drained by placing the water into the sanitary sewer system because of the high chlorine level in the water used to clean the tank. At that time, the overflow line drain outside the tank may not have been completely assembled.

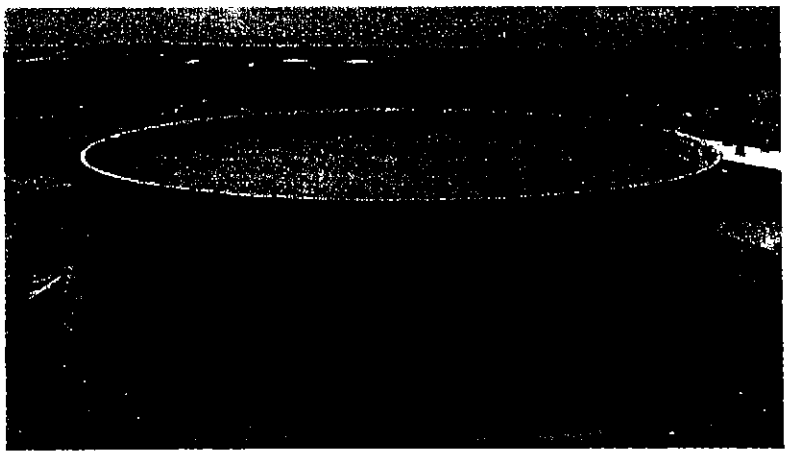


Figure 5. Water level within the tank at approximately 9:30 a.m., after initial draining of the tank.

Investigation

As noted, the tank was at or near the full level at the time of the roof collapse. Thus, the roof structure would have fallen into water estimated to be in excess of 6 m. The water would have served to cushion the fall of the roof structure.

Our review of the debris from the collapse indicates the roof structure displaced vertically to rest on the bottom of the tank. Further review indicated the following:

- The top of the tank walls sustained damage at several locations from impact during the collapse of the double tees (Fig. 6). During the collapse, the double tees appear to have rotated downward about the wall ledge support to impact and damage the tank walls.

- None of the continuous ledges constructed into the precast walls to support the precast solid planks and double tees exhibited failure (Fig. 7). At five locations, the double tee stems reportedly had less than 0.102 m bearing support. As a result, the support was supplemented with a prefabricated structural steel bracket bolted to the vertical face of the wall. None of these brackets exhibited failure.

- The precast columns extended over the roof structure debris. Although the top of the columns and perhaps the bottom had displaced laterally, the haunches, reinforced internally with structural steel, did not exhibit failure (Fig. 8). Some of the haunches did exhibit concrete spalling at the bottom edge.

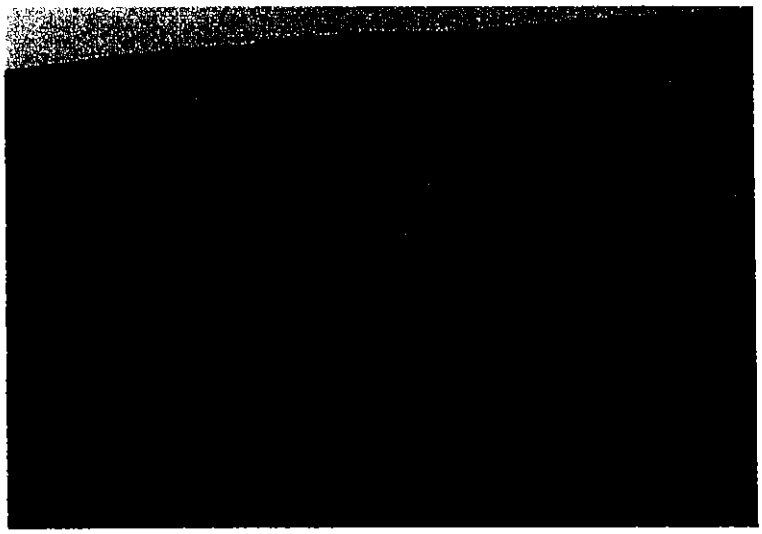


Figure 6. Localized damage at the top of the tank wall attributed to the roof collapse.

Figure 7. Wall ledges that exhibited no damage from the support of the precast members.

EXHIBIT B, PAGE 9 OF 13

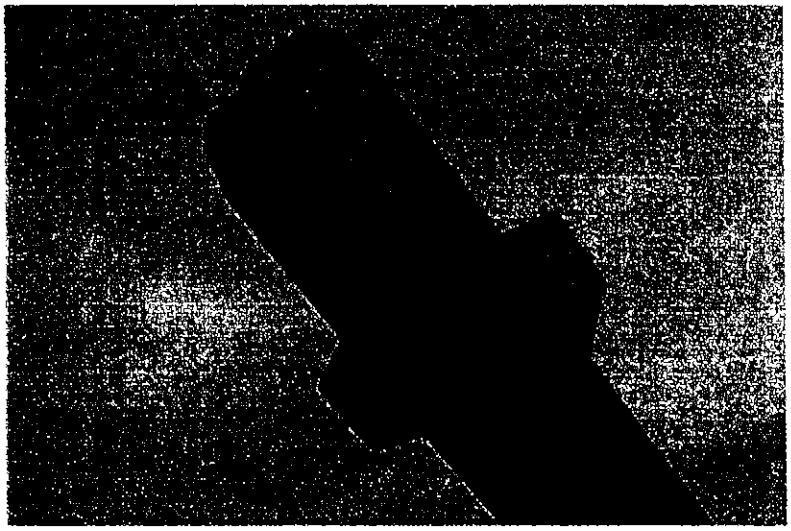


Figure 8. Typical haunches at the top of the precast columns did not exhibit damage.

- Although the weld connections to the columns had fractured, the precast inverted tees appeared to be in relatively good condition (Fig. 9).

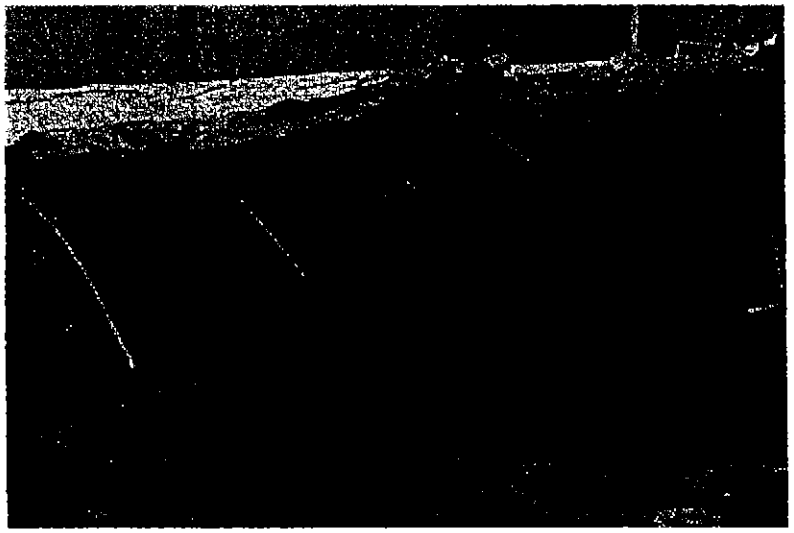


Figure 9. Typical precast inverted tees that did not exhibit significant damage during the collapse.

- The precast rectangular beam extending between the column haunch and the wall ledge to support the precast plank on the south side of the tank exhibited extensive damage from flexure.

- A large percentage of the precast double tees exhibited extensive damage from flexure. The flange section along with the cast-in-place topping was cracked extensively to produce plan sections approximately 0.152 m to 0.203 m in size (Fig. 10). Extensive cracking was sustained in the stems of the double tees (Fig. 11). Aside from the diagonal cracking near the ends, the remainder of the stem had completely separated from the upper section.

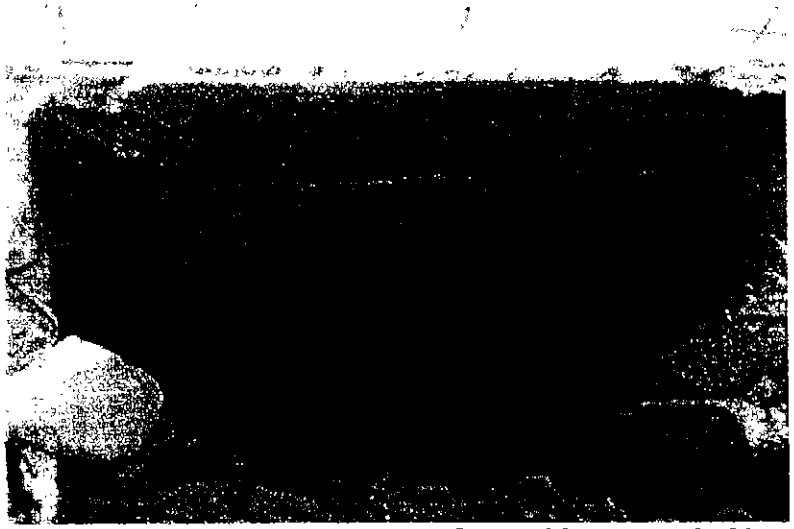


Figure 10. Typical cracking within the flange of the precast double tees.

Figure 11. Typical damage to the stem of the precast double tees.

EXHIBIT B, PAGE 11 OF 13

Structural Evaluation

A cursory structural evaluation was undertaken of the design of the roof structure. The review was based on the calculations and shop drawings furnished by Smithbridge, the sub-contractor responsible for the design and fabrication of the precast and prestressed elements. Because of the damage exhibited by the precast, prestressed beams and double tees, these members were selected for our review. Our analysis indicates the design of the beam and double tees complied with the requirement of the ACI 318-02 for roof structure application with a design live load of 0.96 kPa.

Collapse Assessment

Based on our inspection of the tank and the debris, the collapse is a result of gross overloading of the roof structure at load levels significantly higher than the design live load. The overloading caused the rectangular roof beams and double tees to be grossly overstressed. The distress to the double tees most likely initiated the collapse. The displacement of the double tees had the potential to produce an unstable condition in the remaining roof structure. Further, the displacement of the double tees had the potential to drag down the remaining roof structure because of the continuity of the reinforcement within the concrete topping. The gross overloading of the roof structure in excess of the design live loads is attributed to the absence of air vents within the tank.

Discussions

Our assessment of the collapse is the roof structure was grossly overloaded. This overloading is attributed to the absence of air vents during the removal of air and/or water from within the tank. During the filling of the tank, the overflow drain can serve as a vent for the tank. After filling of the tank, the roof structure is in equilibrium with the atmospheric pressure of 101.3 kPa. Upon the removal of air and/or water from the tank, the internal pressures at the underside of the roof will be less than the atmospheric pressure due to the absence of air vents. The difference in pressures can produce loading of the roof structure in addition to the gravity (weight) loads associated with the tank roof. A reduction in internal pressures of 27.58 kPa produces the same loading effect on the tank roof. A water drawdown of 0.152 m and 0.305 m from the full level produces a load effect of 16.186 kPa and 27.911 kPa, respectively. These values significantly exceed the design live load of 0.96 kPa for the roof structure. It is our assessment that overloads in excess of three to five times the design live loads have the potential to produce collapse to the roof structure.

Our collapse assessment is based on the absence of air vents for the tank as no vents were specified and none was constructed. In addition, the roof surface was completely sealed with a fluid applied waterproofing membrane reinforced with a fabric. After filling of the tank, several fire hydrants were reportedly opened to circumvent water from the wells to the tank. It was reported that opening of the hydrants to discharge the water has a potential to produce an air suction within the supply line that fills the tank. This suction has the potential to reduce the atmospheric pressure within the tank. As mentioned, the supply line daylights over the maximum water level within the tank. With the tank previously filled beyond the overflow level, the overflow drain cannot serve as a vent because the line is crimped to function as a check valve and daylights into a manhole that was full of water from the prior use of the overflow drain.

With water in the manhole, reduction of the atmospheric pressure within the tank has a potential to draw water up the line of the overflow drain, assuming absence of the crimped end functioning as a check valve. However, our calculations indicate a 27.58 kPa reduction in atmospheric pressure within the tank will draw water up the overflow drain line only 2.82 m.

From our analysis of the roof structure, the precast, prestressed members with the cast-in-place bonded topping have sufficient structural capacity to support the design live load for the roof. Based on this condition, we have eliminated the potential of the roof structure collapsing under its own weight with the absence of live loads. This condition is highly improbable given the fact that the precast roof members initially supported the weight of the wet concrete comprising the 76 mm thick topping. Further, on curing the topping increases the capacity of the precast members.

Repairs

The collapse of the tank roof will require removal and replacement. However, the remainder of the tank appears to be unaffected by the collapse as indicated by its continued water tightness. With respect to the damage to the top of the tank walls at several locations, these areas should be sounded to identify cracked and spalled concrete for removal and replacement.

At this time, we have no reservations to reconstructing the roof structure with a similar design to that used initially, with the notable addition of adequate air vents at the top of the tank.

Conclusion

It is our assessment that the collapse of the roof structure is attributed to gross overload due to the absence of air vents that were not specified for the tank. The absence of such vents reduces the atmospheric pressures within the tank during the removal of air and/or water to produce a loading effect on the roof structure. This loading is considered to be grossly in excess of the design live load for the roof structure. Without the vents, the water tank as designed and constructed cannot function in an acceptable and safe manner.